IS THERE A GOLD STANDARD FOR ROTATIONAL ALIGNMENT OF THE TIBIAL COMPONENT DURING TKA?

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INTRODUCTION
A successful total knee arthroplasty (TKA) is dependent on many factors, but component alignment is particularly critical. Aligning the femoral component parallel to the transepicondylar axis is generally regarded as the optimal rotational position, since it has been shown to produce a balanced joint, optimize patellar tracking, and minimize patellofemoral shear forces [1,2]. Unlike the femur, a gold standard for rotational alignment of the tibial component has not been established. A wide variety of landmarks can be used during surgery including the medial border of tibial tubercle, the medial third of the tibial tubercle, the projected femoral transepicondylar axis, the PCL attachment, and the transverse axis of the tibia [3,4]. It is not currently understood how the choice of one of these alignments over the others impacts the stability or kinematics of the TKA knee. The purpose of this study was to examine the relationship of tibial component rotational alignment to passive knee kinematics and stability.

METHODS
We have performed a series of experiments using a custom, image-based surgical navigation system on 9 cadaveric knee specimens containing all structures distal to the pelvis. Prior to testing, all specimens were CT scanned (2 mm slices) in order to precisely locate the transepicondylar axis on the femur and several landmarks on the tibia. We used these data to define 4 tibial axes. The TEA was the projection of the femoral transepicondylar axis onto the tibial plateau with the knee in full extension. The transverse axis (TA) was defined as the line between the most medial and the most lateral points on the tibial plateau. The medial border axis (MBA) and the medial third axis (MTA) were defined as the lines between the PCL attachment and the medial border or the medial one third of the tibial tubercle, respectively.

A TKA was performed on each specimen using a Zimmer Natural Knee PCL-retaining model. After the knee was exposed, optical reference frames were attached to the femur and the tibia and anatomic reference frames were established [5]. The specimen was then registered to the CT data using an iterative closest point method [6] to ensure that the femoral component was rotationally aligned to the transepicondylar axis, while the tibial component was aligned within 1° to the 4 different tibial axes of interest using a customized tibial component.

Passive kinematics and varus-valgus stability data for the knee in full extension were recorded before and after prosthesis implantation. Passive kinematics were recorded as we have done previously [5]. To characterize joint stability, the force-displacement relationship of the knee was measured using the surgical navigation system and a custom stability device (Figure 1) that enabled us to accurately apply known loads and record resultant displacements [7].

Figure 1: Custom stability device used to obtain force-displacement data

Knee stability was evaluated by analyzing the force-displacement curves for varus-valgus laxity (the amount of motion in degrees) under ±10 and ±20 N·m loads and stiffness (slope of the curve) at ±20 N·m [8, 9]. Passive kinematics were analyzed by determining the amount of varus-valgus motion,
screw-home rotation, and anterior-posterior translation while the knee was passively flexed and extended [5]. Repeated measures analysis of variance (ANOVA) was used to determine if tibial rotational alignment has a statistically significant effect on these factors. When a significant effect was present (p≤0.05), Tukey’s test was used to as a post-hoc test.

RESULTS and DISCUSSION
Our study showed that significant differences (p≤0.02) in stability exist between the native knees and the 4 different tibial rotational alignment axes, but there was little change (p≥0.28) based on the rotational alignment of the tibial component (Figure 2). For a given knee, TKA results in a “softer” knee with a 4.6±2.7° average increase in laxity and a 4.0±2.7 N·m/° average decrease in stiffness when a ±20 N·m load is applied.

![Figure 2: Stiffness under 20 N·m load for a representative specimen](image)

Anterior translation of the femur and screw-home motion during passive flexion also showed an increase (p≤0.05) after TKA, but once again, tibial rotational alignment did not appear to affect these parameters (p≥0.28). When comparing native to TKA knees, anterior translation increased by an average of 5.6±4.0 mm and screw-home (5°-105° flexion) increased by 6.7±2.8° on average.

However, varus-valgus motion was affected (p≤0.001) by the rotational alignment of the tibial component in early flexion (Figure 3). Aligning to the MBA or the TA was shown to minimize the valgus deviation between the normal and the TKA knee, but it is debatable whether this small difference (4.2±1.1°) is clinically relevant.

We did note large variability in our measurements between specimens for all 5 conditions. We believe the variability seen across different knees maybe the result of high variability in the tibial anatomy. We discovered that the angle between the most internal and the most external axis across knees ranged from 8.9° to 27.1°, which is similar to other researchers [3]. Additionally, the most internal and external axes were not consistent across specimens.

![Figure 3: Passive kinematics for a representative specimen](image)

CONCLUSIONS
Considering the importance of surgical technique in TKA, our results suggest that surgeons who align the tibial component to any of the axes in this study may be expected to have stability results consistent with their peers who may be using a different axis. Given the large variability between specimens, this study further suggests that there is not a gold standard for the rotational alignment of the tibial component that can be recommended for use on all patients at this time.

REFERENCES